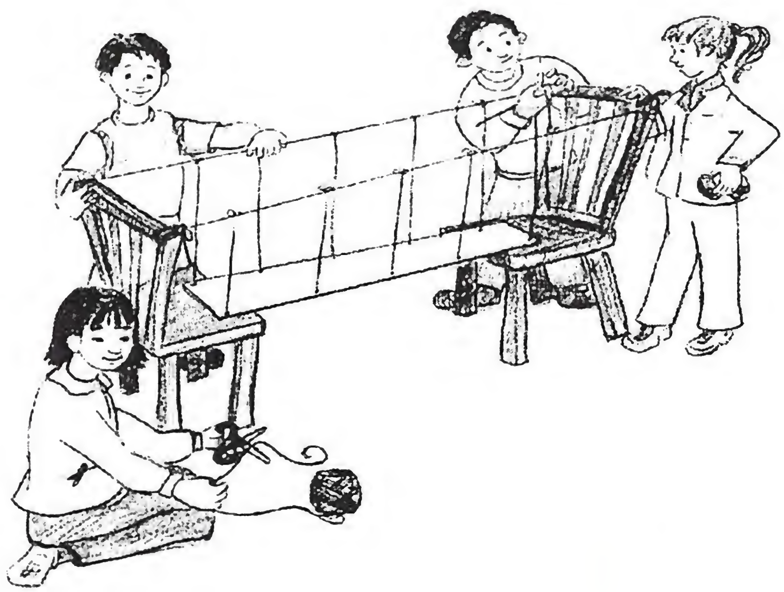
Engineering is Elementary
Engineering and Technology Lessons for Children

Designing Bridges



Duplication Masters

An Introduction to
Civil Engineering
for Elementary Students

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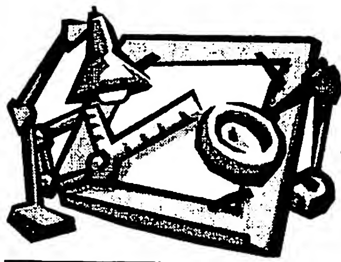


Technology Around Us

What is your object? ____________________

Draw a picture of your object in this box. Label the parts.

What does your object do? or
What problem does your object solve?

____

____

____

What material or materials is it made of?

____

____

Names of Materials

Here are some material names you can use to talk about what things are made of. You can add more material names on the lines.

wood	clay	nylon
paper	brick	plastic
leaf	cement	glass
stone	metal	fur
pebbles	straw	wool
sand	string	bone
silt	rope	leather
soil	cloth	water
dirt	cotton	air

Name: ______________________________ Date:_______________

Working with Technology

People sometimes get confused about the kinds of work that **engineers, technicians,** and **artisan or craftsman** do in their jobs.

An **artisan or craftsman** is a person whose job is to build or make technologies.

An **engineer** is a person whose job is to design new technologies.

A **technician** is a person whose job is to fix technologies (usually engines or machines) or to make them work.

Draw a line from the kinds of work that people do to the person whose job it is to do that work.

	1. Repairs airplanes.
Artisan	
	2. Designs a better toothbrush.
	3. Runs an x-ray machine.
Technician	
	4. Builds houses and stores.
	5. Creates a new kind of wheelchair.
Engineer	
	6. Makes shoes.

Name: ______________________________ Date:_______________

Vocabulary List

Javier: Civil Engineering and Bridges of the United States

beam bridge: ____

____

pier: ____

____

span: ____

____

arch bridge: _______________________________________

____

abutments: ____

____

suspension bridge: __________________________________

____

Name: ______________________________ Date: ______________

Vocabulary Definitions

Javier: Civil Engineering and Bridges of the United States

beam bridge: a bridge made of a flat piece, or beam, laid across two or more piers

pier: a support for a beam bridge that helps to hold up the beam

span: the distance a bridge crosses without any support underneath; the distance between piers

arch bridge: a bridge made from an arch and abutments or multiple arches

abutments: the parts of an arch bridge that stand at either end of the arch and hold the arch in shape

suspension bridge: a bridge made of a platform that is held up by wires or ropes strung from the tops of piers, often called towers

Name: ______________________________ Date: _______________

Engineering Problems Chart

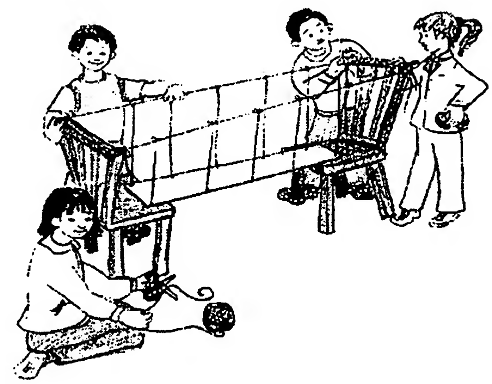
What did the **engineers** design?	What were the **requirements** for the design?	What was the **solution**?
Javier's beam bridge		
Lake Pontchartrain Bridge		
Natchez Trace Bridge		
Roman bridge		
Golden Gate Bridge		

Engineering Problems Chart
Answer Key

What did the **engineers** design?	What were the **requirements** for the design?	What was the **solution**?
Javier's beam bridge	**Sample Answers:** easy to build; not permanent; not covering the stream	a log across the stream
Lake Pontchartrain Bridge	**Sample Answers:** cross a very wide lake; strong enough to hold lots of cars	lots of short beam bridges put together
Natchez Trace Bridge	**Sample Answers:** beautiful; support lots of people and cars	an arch bridge
Roman bridge	**Sample Answers:** need something strong	an arch bridge
Golden Gate Bridge	**Sample Answers:** cross a big harbor; stronger than winds, tides, and earthquakes	a suspension bridge

Name: ______________________________ Date:______________

Javier the Engineer

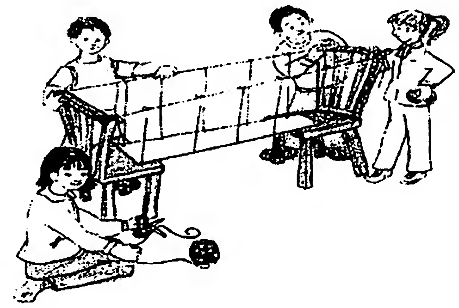


To improve their designs, engineers test and redesign technologies many times.
How did Javier and his friends test their suspension bridge?
Write or draw to explain.

How could they have made it better? Write or draw to explain.

Name: ______________________________ Date: ______________

Javier the Engineer



Write answers to the questions about the story.

1. Where does Javier live?

____

____

2. What is his dad's job?

____

____

3. What do civil engineers do?

____

____

4. What things did Javier design and build?

____

____

5. What does Javier want to be when he grows up?

____

____

Name: ______________________________ Date:______________

An Engineer is a Person Who...

Circle the item that best describes what engineers would do for their work. Cross out the other item.

1. a. Fixes people's cars.
   b. Improves the design of cars.

2. a. Designs computers.
   b. Repairs computers.

3. a. Builds houses for people.
   b. Designs new buildings.

4. a. Invents something because she feels like it.
   b. Invents something that solves a problem.

5. a. Puts wires and electricity into houses.
   b. Figures out how to make more electricity.

6. a. Makes prototype trains and machines.
   b. Drives trains and machines.

Give your own example of what an engineer does.

____

____

____

____

Name: ______________________________ Date:_______________

Balancing a Suspension Bridge

Draw or explain the first design of your suspension bridge.

____

____

____

____

____

Draw or explain the **redesign** of your suspension bridge.

____

____

____

____

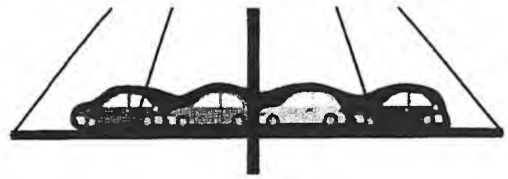
What did you change?____________________________________

____

How did this improve the stability of the bridge?_____________

____

Name: ______________________________ Date: _______________



Testing a Suspension Bridge

What happened to your bridge during and after

a windstorm? (Forces pushing sideways.)

____

____

an earthquake? (Forces rocking the towers.)

____

____

falling rocks? (Forces acting downward.)

____

____

How many weights can your bridge support and still be stable? (More forces acting downward.)

____

____

____

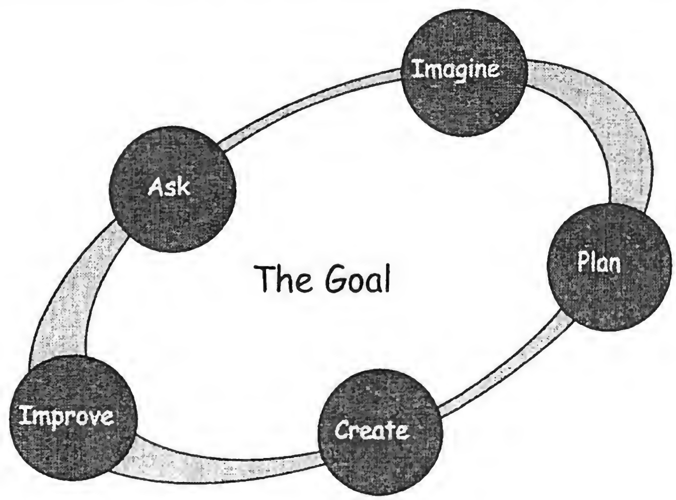
Name: ______________________ Date: ____________

Testing Bridge Designs

Draw pictures of the bridge shapes you tested. Explain what happened to your bridges when you tested them. How much weight could each bridge hold?

Shape	Weight it Could Hold	What happened when it failed?

The Engineering Design Process:
Five Steps for Engineering Design



Ask: What do you want to do? What is the problem?

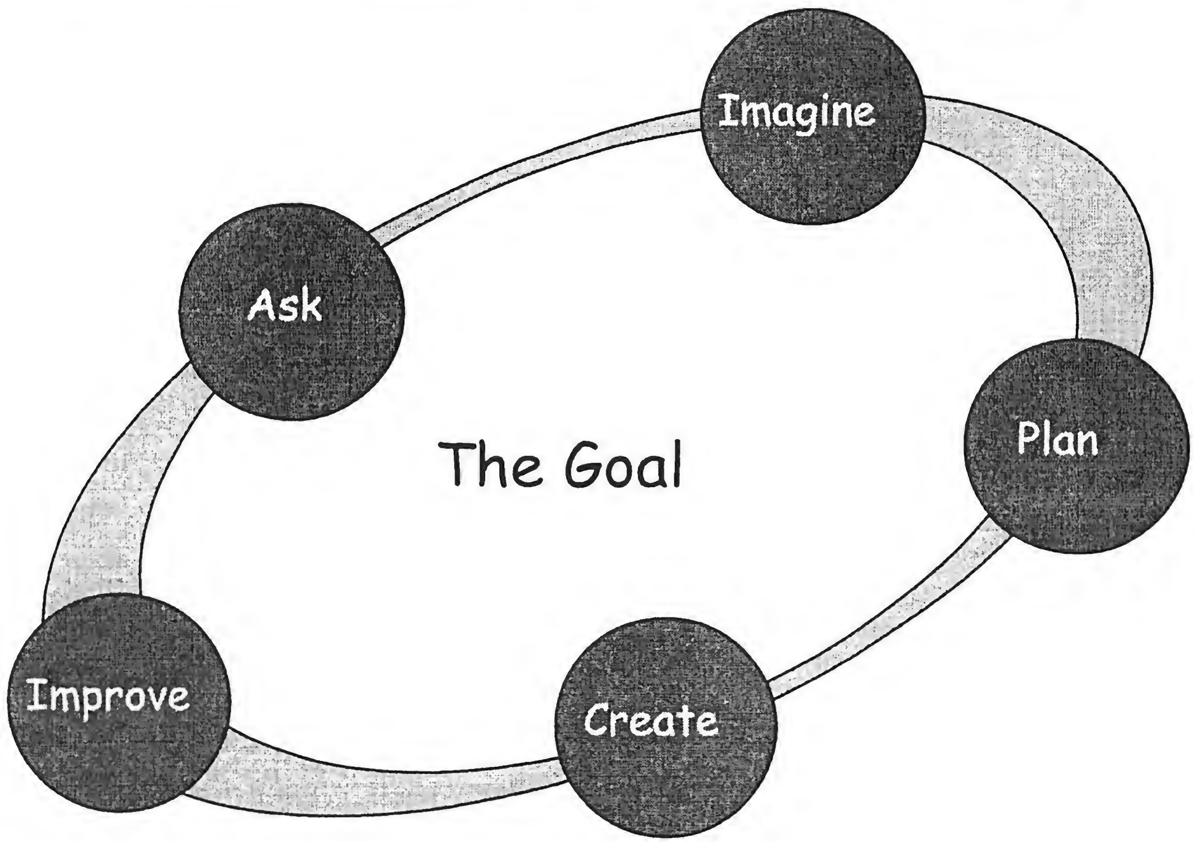
Imagine: What could be some solutions? Brainstorm lots of ideas. Pick one to start with that you think will work best.

Plan: Draw a diagram of your idea. Make lists of materials you will need to make it. Decide how you will know it works. How will you test it?

Create: Build a prototype. Test it. Talk about what works, what doesn't, and what could work better.

Improve: Talk about how you could improve your product. Draw new designs. Create a new prototype. Make your product the best it can be.

The Engineering Design Process: Five Steps for Engineering Design



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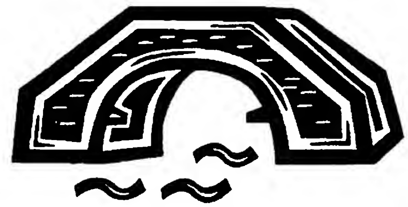


Our Own Bridge

Engineering Design Process: Ask!

The purpose of our bridge is:

____

____

Our bridge needs to be:

____

____

The materials we can use are:

____

____

____

We will test our bridge by:

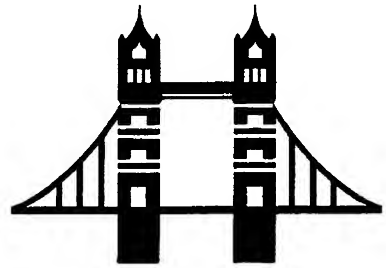
____

____

Name: ______________________________ Date:_______________

Our Own Bridge

Engineering Design Process: Imagine!

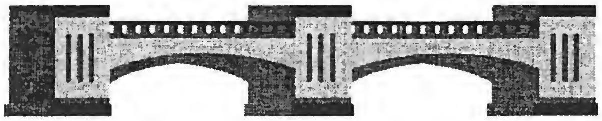


What will you do to solve the problem? Draw pictures of your ideas below or list your ideas on the back of this sheet. Circle the idea you think will work best.

Our Own Bridge
Engineering Design Process: Imagine!
(page 2)

List your bridge ideas.
Circle the idea you think will work best.

Name: ______________________________ Date: _______________



Design #

Our Own Bridge
Engineering Design Process: Plan!

Draw a diagram of your plan.
Label each part.

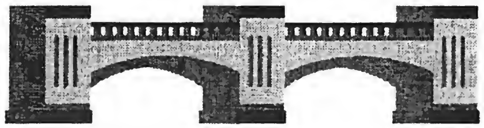
List the materials you will need.

____

____

____

Name: ______________________ Date: ____________



Design #

Our Own Bridge
Engineering Design Process: Plan!

Draw a diagram of your plan with labels.

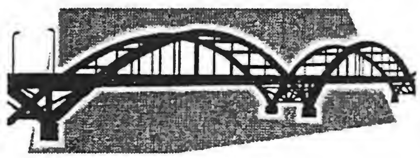
Our Own Bridge
Engineering Design Process: Plan! (page 2)

Material Name	Cost of Material		How many?		Total Cost of Material
______	______	×	______	=	______
______	______	×	______	=	______
______	______	×	______	=	______
______	______	×	______	=	______
______	______	×	______	=	______
______	______	×	______	=	______
______	______	×	______	=	______
______	______	×	______	=	______

Total Cost: ☐

Name: ______________________________ Date:_______________

Our Own Bridge
Engineering Design Process: Create!



Design #

How did you test your design?

____

____

What happened when you tested it?

____

____

What parts of your design worked?

____

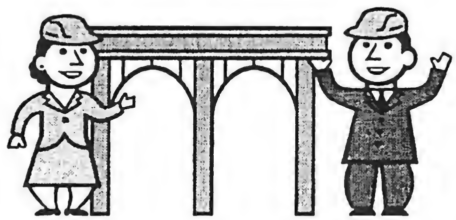
____

What parts of your design did not work?

____

____

Name: ______________________________ Date: ________________



Our Own Bridge

Engineering Design Process: Improve!

Design #

Ask Again

Does your design solve the problem? __________

What parts of the problem still need to be solved?

____

____

____

Imagine Again

What can you do to improve your design?

____

____

____

Plan Again

Use a new "Engineering Design Process: Plan!" to plan again.

Name: ______________________________ Date:_______________

Bridge Design Evaluation: Scoring Instructions

Strength Score: How many weights did your bridge hold before it became distorted?

Score of 1: fewer than ______

Score of 2: between _____ and _____

Score of 3: between _____ and _____

Score of 4: between _____ and _____

Score of 5: more than _____

Stability Score: How many times, in three trials, did your car successfully roll across the bridge?

Score of 1: once

Score of 2: twice

Score of 3: three times

	Design #___	**Design #___**	**Design #___**
Strength Score			
Stability Score			
Total Score			

Name: ______________________________ Date:_______________

Bridge Design Evaluation: Scoring Instructions

Strength Score: How many weights did your bridge hold before it became distorted?

> **Score of 1:** fewer than ______
> **Score of 2:** between _____ and _____
> **Score of 3:** between _____ and _____
> **Score of 4:** between _____ and _____
> **Score of 5:** more than _____

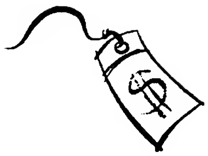
Cost Score: Choose the score for the cost of your design.

> **Score of 1:** $10 or more
> **Score of 2:** between $8 and $10
> **Score of 3:** between $6 and $8
> **Score of 4:** between $4 and $6
> **Score of 5:** less than $4

Stability Score: How many times, in three trials, did your car successfully roll across the bridge?

> **Score of 1:** once
> **Score of 2:** twice
> **Score of 3:** three times

	Design # ____:	**Design #____:**	**Design #____:**
Strength Score			
Cost Score			
Stability Score			
Total Score			



Bridge Materials Price Sheet

These are the materials you may use to build your bridge, and their costs:

one craft stick.......................................$1.00

one sheet of paper (8 1/2" × 11") $0.50

one straw...$0.50

one piece of tape.................................$0.10

one paper clip.......................................$0.10

6 inches of string...................................$0.10

Evaluating Student Learning: A Rubric for Lesson 1

Student will be able to...	Novice 1	Apprentice 2	Proficient 3	Distinguished 4
identify engineering problems and solutions.	Student does not successfully identify engineering problems or solutions.	Student is able, with support, to identify some engineering problems and/or solutions but also gives inappropriate responses.	Student successfully identifies engineering problems and solutions with minimal support by the end of the activity.	Student participates at proficient level. Also makes connections to his/her life, and/or articulate insights beyond the story.
recognize civil engineers' role in designing structures.	Student does not successfully recognize the role of civil engineers, or contributions are inappropriate.	Student participates but with many hesitant or confused responses. Student needs significant support to generate contributions.	Student participates readily and appropriately. Student contributes solid explanation of the role of civil engineer in at least two areas.	Student participates at proficient level, and is also able to make connections and articulate insights beyond the activity.
discuss requirements for designs.	Student does not show evidence of understanding of requirements for designs and how engineers must work with requirements.	Student participates but with many hesitant or confused responses. Student needs significant support to generate contributions.	Student participates readily and appropriately. Student contributes solid explanation of requirements that engineers must work with.	Student participates at proficient level, and is also able to make connections and articulate insights beyond the activity.
participate in discussion.	Student participates minimally in discussion.	Student participates but with many hesitant or confused responses. Student needs significant support to generate contributions.	Student participates readily and appropriately in the class discussion.	Student is engaged in the class discussion and shares insights and connections beyond the story and the classroom.

Evaluating Student Learning: A Rubric for Lesson 2

Student will be able to...	Novice 1	Apprentice 2	Proficient 3	Distinguished 4
construct a suspension bridge with constraints.	Student is reticent to try without support; or does not experiment to find improved ways to support the bridge with given constraints.	Student is able, with support, to experiment and construct a suspension bridge that may or may not be stable.	Student experiments and constructs a suspension bridge that may or may not be an improvement over the first try.	Student draws conclusions from first experiment with supports to make an improved bridge on subsequent tries.
observe and describe the performance of a suspension bridge.	Student does not successfully observe and describe the performance of suspension bridges with different string supports.	Student needs support. Descriptions are vague or do not refer to observations.	More than half of descriptions are appropriate and detailed.	Observations include multiple details. More than half of descriptions include appropriately varied and specific vocabulary.
test the stability of the suspension bridge by having forces act on it.	Student does not appropriately describe or show understanding of how forces act on the suspension bridge.	Student needs support to describe how forces affect the bridge during testing.	Student shows understanding of how the test is demonstrating how the bridge reacts to forces. Can describe how forces affect the bridge. Reasoning is sound.	Student makes an attempt to explain what happens in terms of his or her experience beyond the activity. Reasoning is sound and shows attention to multiple aspects of the experiment.
experiment, trying to meet criteria.	Student does not compare results from different experiments with string supports, or comparisons are weak, unjustified.	Student is able, with support, to compare results. Comparison refers to details from observation.	Student successfully compares results from experimentation with string supports, referring to details from observation. Is able to draw relevant conclusions.	Student performs at proficient level, and in addition is able to draw relevant conclusions that are supported by observations and other connections beyond the classroom and activity.

Evaluating Student Learning: A Rubric for Lesson 3

Student will be able to...	Novice 1	Apprentice 2	Proficient 3	Distinguished 4
observe and describe the performance of three bridge types.	Student does not successfully observe and describe the performance of different bridge types.	Student needs support. More than half of descriptions are incomplete, or do not include specific vocabulary.	More than half of descriptions are appropriate and detailed.	Observations include multiple details. More than half of descriptions include appropriately varied and specific vocabulary.
analyze and compare the performance of different bridge types for holding weight.	Student does not analyze the properties of bridge types in terms of their ability to hold weight. Student does not appropriately compare the performance of bridges.	Student needs support to analyze and compare the properties of different bridge types. Analysis is not justified. Reasoning is weak.	Student is able to analyze the properties of bridge types, comparing them in terms of how much weight each can hold. Reasoning is sound. Comparison refers to details from observation.	Student makes an attempt to explain the analysis in terms of his or her experience beyond the activity. Reasoning is sound and shows attention to multiple aspects of the experiment.
recognize that the shape of a bridge affects how well it can distribute forces and hold weight.	Student does not demonstrate that he or she understands that the shape of a bridge affects how well it can hold weight.	Student is able, with support, to discuss how the shape of a bridge affects its ability to distribute forces and hold weight. Reasoning is weak.	Student successfully explains how shape affects the ability of a bridge to distribute forces and hold weight. Reasoning is sound.	Student performs at proficient level, and in addition is able to discuss connections beyond the activity or contribute other insights.
compare results of a controlled experiment.	Student does not compare results from different bridges in the experiment, or comparison is weak, unjustified.	Student is able, with support, to compare results. Comparison refers to details from observation.	Student successfully compares results from the experiment, talking about both variable and controlled parts of the experiment.	Student performs at proficient level, and in addition is able to discuss discrepant results or contribute other insights.

Evaluating Student Learning: A Rubric for Lesson 4

Student will be able to...	Novice 1	Apprentice 2	Proficient 3	Distinguished 4
identify the steps of the EDP.	Student does not use EDP steps.	Student uses EDP steps with support, but not building from one step to another.	For the most part, student uses each step of the EDP as support for the next.	Student uses all EDP steps, showing productive flexibility in application.
brainstorm several design ideas.	Student does not participate in brainstorming; suggestions are weak or fanciful.	Student participates in brainstorm with some ideas that follow from earlier work but may need help expressing them.	Student contributes many different types of design ideas; ideas are sensible given earlier work on the topic.	Student contributions at proficient level and shows flexibility and insight into how different kinds of ideas can be useful.
create a detailed plan with materials list and labeled diagram.	Plan lacks detail; is difficult to understand.	Plan has some detail, but many aspects of the plan (consistent labeling, full materials list, etc.) are missing.	Plan has a good amount of detail. Labeling of parts and materials makes plan easy to follow, though some clarifications may be needed.	Plan is well executed, complete, and easy to understand. Includes extra views and explanation of more complicated parts.
create a prototype from a design.	Prototype does not match design plan; prototype doesn't meet requirements.	Prototype partially matches design plan **or** prototype meets some requirements.	Prototype mostly matches design plan **and** prototype meets some or all requirements	Where prototype does not match plan, reasons are given **and** prototype meets all requirements.
test and analyze a prototype for strengths and weaknesses.	Tests are poorly conducted and recorded; student is unable to analyze strengths and weaknesses of prototype without help.	Tests are somewhat well conducted and recorded; student analyzes a few strengths and weaknesses of prototype but may need some support.	Tests are carefully conducted and recorded; student analyzes many strengths and weaknesses of prototype .	Proficient performance **and** student analysis shows insight into how the nature of the tests, construction and/or the design affects prototype performance.
improve a design.	Student does not improve design based on earlier results.	Student is able to make a few improvements based on earlier results.	Student makes significant improvements based on analysis of earlier results.	Student makes principled improvements to the design based on analysis.